DY 63: Nonlinear Stochastic Systems

Time: Friday 11:30–12:45 Location: ZEU/0118

DY 63.1 Fri 11:30 ZEU/0118

Stochastic Dynamics of Noisy Oscillators under Eigenfunction Transformation — •Georg Podhaisky[1,2], Alberto Pérez-Cervera[3], and Benjamin Lindner[1,2] — [1]Bernstein Center for Computational Neuroscience, Berlin, Germany — [2]Humboldt University, Berlin, Germany — [3]Universitat d'Alacant, Alicante, Spain

Stochastic oscillations are observed for a wide range of systems in biology and physics. Although their dynamics may vary drastically, a simple approach for a unified description exists. As recently demonstrated by Pérez-Cervera et al. (PNAS 120, 2023), the first non-trivial eigenfunction $Q_1^*(\mathbf{x})$ of the Kolmogorov backward operator, which is obtained from the adjoint Fokker-Planck equation, can be used as a particularly useful transformation rule: This eigenfunction maps the trajectories of a given stochastic oscillator to a complex-valued domain. In this domain the autocorrelation statistics as well as the system's linear response are characterized by simple and qualitatively universal functions, regardless of the original dynamics. Here we study the stochastic dynamics in the $Q_1^*(\mathbf{x})$ domain, specifically, a number of two-dimensional systems including the Stuart-Landau oscillator and the harmonic oscillation with damping and thermal noise.

DY 63.2 Fri 11:45 ZEU/0118

Impact of heavy-tailed synaptic strength distributions on self-sustained activity in networks of spiking neurons — •Ralf Tönjes — Humboldt Universität, Berlin, Deutschland

We analyze states of stationary activity in randomly coupled quadratic integrate-and-fire neurons using stochastic mean-field theory. Specifically, we consider the two cases of Gaussian random coupling and Cauchy random coupling, which are representative of systems with light- or with heavy-tailed synaptic strength distributions. For both, Gaussian and Cauchy coupling, bistability between a low activity and a high activity state of self-sustained firing is possible in excitable neurons. In the system with Cauchy coupling we find analytically a directed percolation threshold, i.e., above a critical value of the synaptic strength, activity percolates through the whole network starting from a few spiking units only. The existence of the directed percolation threshold is in agreement with previous numerical results in the literature for integrate-and-fire neurons with heavy-tailed synaptic strength distribution. However, we have found that the transition can be continuous or discontinuous, depending on the excitatory-inhibitory imbalance in the network. Networks with Gaussian coupling and networks with Cauchy coupling and additional additive noise lack the percolation transition in the thermodynamic limit.

DY 63.3 Fri 12:00 ZEU/0118

Stochastic thermodynamics of bifurcations in all-to-all interacting systems — •Ankita Gupta[1] and Aljaž Godec[1,2] — [1]Mathematical Physics and Stochastic Dynamics, Institute of Physics, University of Freiburg, 79104 Freiburg im Breisgau, Germany — [2]Mathematical bioPhysics Group, Max Planck Institute for Multidisciplinary Sciences, Am Fassberg 11, 37077 Göttingen, Germany

All-to-all interacting systems provide a fundamental framework for understanding cooperative behavior and synchronization. Here, we examine the stochastic thermodynamics of such systems in continuous space as they are driven across bifurcation. Our analysis centers on the total entropy production rate (tEPR), which quantifies the thermodynamic cost of maintaining or transitioning between different dynamical phases. Focusing on the microscopically reversible Desai-Zwanzig model and irreversible Bonilla-Casado-Morillo models, we investigate how the tEPR depends on microscopic parameters-including interaction strength, temperature, and external driving. Leveraging recent advances on the Onsager-Machlup functional for McKean-Vlasov stochastic differential equations, we study path measures and characterize dynamical fluctuations near criticality. Through a combination of phase-plane methods and numerical simulations, we reveal the structure and nature of the bifurcations across a range of parameter regimes.

DY 63.4 Fri 12:15 ZEU/0118

Estimation of typical time scales in a Langevin-type model for wind turbine power conversion — •Martin Wagner and Joachim Peinke — Carl von Ossietzky Universität Oldenburg, School of Mathematics and Science, Institute of Physics, ForWind - Center for Wind Energy Research, Küpkersweg 70, 26129 Oldenburg, Germany

In the recent years, a data-driven and computationally efficient Langevin approach has been successfully used to detect physically reasonable fixed points in the short-term power conversion dynamics of wind turbines [1]. In our contribution, we aim to use this model to describe the multi-body interaction and possible synergy effects of the power production of many turbines in a wind farm. Additionally to the fixed points, this requires the extraction of the typical inertial time scales of the power conversion from the stochastic model. We find that this is difficult, since the model does not fulfil the Markov property due to a projection that induces a memory kernel to the stochastic differential equation according to the Mori-Zwanzig formalism [2]. Nevertheless, we show that upper boundary estimates for the typical inertial time scales of a wind turbine can be extracted from the stochastic model. In the future, this is a first step towards the stochastic modelling of many turbines, e.g. to model a grid-supportive power production of a whole wind farm.

[1] Milan P, et al. Phys Rev Lett. 2013;110(13):138701.

[2] Zwanzig R. Nonequilibrium Statistical Mechanics. Oxford University Press; 2001. p. 149 ff.f.

DY 63.5 Fri 12:30 ZEU/0118

Universal Kardar-Parisi-Zhang scaling in non-equilibrium magnon condensates — •Alexander Wowchik and Achim Rosch — Institute for Theoretical Physics, University of Cologne, Zülpicher Str. 77, 50937 Köln, Germany

Extensive studies in the past decade have unveiled how driven-dissipative condensates in one and two dimensions can form a unique non-equilibrium phase of matter characterized by a Kardar-Parisi-Zhang (KPZ) equation for the emergent Goldstone modes. We investigate whether the condensation of magnons, as demonstrated in Yttrium Iron Garnet (YIG) films when driven with microwave radiation, is a suitable candidate to study such phenomena. Via micromagnetic simulations of a corresponding system, we show that, after strong initial pumping, the dynamical autocorrelation function of the magnon field exhibits the universal scaling exponent predicted by the KPZ equation.